ULTRASONIC WELDING PROCESS AND EQUIPMENT FOR CONSTRUCTION OF ELECTRON-TUBE MOUNTS

Ninth Quarterly Progress Report
For the Period
July 1 through September 30, 1964

Contract No. DA-36-039-sc86741
Order No. 19063-PP-62-81-81

Placed by
Industrial Engineering Division
United States Army Electronics Command
225 South Eighteenth Street
Philadelphia, Pennsylvania

AEROPROJECTS INCORPORATED
West Chester, Pennsylvania

No DDC limit.

AEROPROJECTS INCORPORATED

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The object of this program is to design and construct prototype welding equipments and their associated accessories to perform by ultrasonic techniques the welding operations required in the assembly of electron tubes.

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Specifications SCS-114A, SCIPPR-15
and MIL-E-1/1121A

Report Prepared by: J. L. Thomas

Report Approved by: Byron Jones

ABSTRACT

All of the connections in the modified Type 6080WB electron tube have been accomplished by ultrasonic welding with a standard 600-watt welding machine, special tips and anvil tooling. Welding equipment has been delivered to Tung-Sol Electric Incorporated, and the complete assembly sequence required to make the ultrasonically welded tube mount has been demonstrated by Aeroprojects' personnel. Welding investigations with molybdenum wire wound frame grids have been limited to tooling design studies. Welding investigations will be initiated upon receipt of wound frame grids from Tung-Sol. Welding studies which involve ultrasonic bonding of 0.003-inch diameter tungsten-3 rhenium wires to molybdenum, tungsten, and nickel in 0.060-inch flat sheet are progressing satisfactorily, and final samples for shock and vibration testing will be prepared after minor welder tooling modifications such as grooving of tip and substitution of tip material from tool steel to Udimet 700 are completed.

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PURPOSES

The objectives of this Production Engineering Measure (PEM) are to:

1. Demonstrate the capability limits of ultrasonic welding to join combinations of metallic materials of interest to the electron-tube industry. Devote major effort to making satisfactory joints in materials and geometries which might be difficult or impossible to join by other means.

2. Analyze the welding requirements for a specific electron tube - Type 6080WB. This type was selected by the U. S. Army Electronics Command because it has a record of rejects and failures due to metallic splatter caused by conventional welding techniques and improperly welded joints.

3. Redesign components of the Type 6080WB electron-tube where possible, to permit ultrasonic welding of joints previously found impractical. This effort will result in a tube mount with as many metal-to-metal joints as possible produced by ultrasonic welding so that evaluation of electron-tube performance will not be confused by the influence of metal-to-metal joints produced by other welding or joining techniques.

4. Determine the feasibility of joining 0.003-inch gold-plated molybdenum grid wires to 0.060-inch molybdenum side bars by ultrasonic welding for frame grid manufacture. If successful, redesign applicable components of the Type 6080WB electron-tube mount to permit the use of frame grids.

5. Prepare fixturing and tooling for the Type 6080WB electron tube, compatible with ultrasonic welding equipment.

6. Ultrasonically weld the parts required to assemble electron-tube mounts for the 6080WB tube type, and compare results obtained against similar sub-assemblies made by conventional joining methods. Tests will include strength and environmental tests.

7. Build production ultrasonic welding equipment which will enable an electron-tube manufacturer to make the welded connections in a broad range of electron-tube types.

8. Install the ultrasonic welding equipment in a production company, and produce on a pilot basis with that company's personnel, a limited lot size of Type 6080WB electron tubes for subsequent evaluation in accordance with the applicable military specification.

NARRATIVE AND DATA

I. ELECTRON TUBE STUDY

A. Type 6080WB Electron Tube Redesign

The three joint configurations of the Type 6080WB electron tube which presented initial difficulty have been reexamined during this period, and successful welding has been achieved in two areas. The third junction, the grid radiator to grid (Assembly Sequence No. 8, Quarterly Progress Report No. 6, page 12) has been eliminated by the tube manufacturer after consideration of minor tube redesign. The two getters have been relocated (getters to snubber supports; assembly Sequence No. 22) to allow a parallel-wire weld between the getter frame and snubber support rod. The position of the upper four snubbers has been also slightly altered (snubber to snubber supports; Assembly Sequence No. 18) and tooling has been designed to accomplish ultrasonic welding of these connections.

The modified Type 6080WB electron tube incorporates the following changes as of this report period:

1. Eliminate splash spacer and four (4) splash spacer supports.
2. Eliminate spacer cathode connector subassembly.
3. Modify the two (2) top cathode connectors.
4. Change location of two (2) getters.
5. Shorten two (2) snubber supports from 56 mm to 39 mm.
6. Shorten cathode connector snubber support from 56 mm to 45 mm.
7. Weld cathode tab on top spacer to connector.
8. Relocate upper four (4) snubbers.
9. Shorten four (4) anode supports from 45 mm to 41 mm.

B. Getter Assembly

Joining of the getters to the snubber support rods of the Type 6080WB tube, which was reported earlier as unsuccessful because of the cross-wire weld geometry (Quarterly Progress Report No. 6), has been accomplished by a parallel-wire welding approach. The 0.035-inch diameter "D" nickel (annealed) getter frame welded to the 0.040-inch 1/2 H "D" nickel snubber support rod is shown in Figure 1. Special tooling developed for this welding step is shown in Figure 2 (A and B). The excellent bond quality achieved in sample welds is evident in the photomicrographs presented in Figure 3.

C. Snubber Assembly

Ultrasonic welding of the snubbers (hard temper Inconel) to the snubber support rods (1/2 hard "D" nickel) has been accomplished successfully without distortion of the support rod. Tooling developed for this welding sequence is shown in Figure 4. The anvil support is contoured to fit the

cage assembly of the Type 6080WB tube and can be positioned to weld both the top and bottom snubbers as shown in Figure 5. Photomicrographs of representative welds, shown in Figure 6, indicate excellent bond quality without serious distortion of the snubber. The snubber support rod is locally deformed in the weld area, assuring a large area weld spot.

II. TUNG-SOL ACTIVITY

The 100-watt ultrasonic welder and the 600-watt unit complete with special tools for fabrication of the Type 6080WB electron tube were delivered to Tung-Sol Electric Incorporated, Bloomfield, New Jersey, on August 3, 1964. Installation and setup of the equipment in the Development Section of the Tung-Sol plant were performed by Aeroprojects personnel on August 19, 1964. Welding procedures were reviewed and the assembly sequence and special tools used in the assembly of the Type 6080WB tube mount were demonstrated to Messrs. N. Helmstetter and A. Cuculo of Tung-Sol on August 20 and 21, 1964.

The 100-watt unit was used in an auxilliary manner to demonstrate the effect of ultrasonics on the ease of insertion and removal of the anode support rods from the carbon anodes of the Type 6080WB tube (Seventh Quarterly Progress Report). Difficulty with the fit obtained between the anode support rod and the anode is frequently experienced in the manufacture of this tube. Variation in tolerances of vendor-supplied material is such that oversize anode support rods and/or undersize bores in the carbon anodes make it necessary to force-fit the assembly. Breakage or cracking of the anode frequently occurs during assembly and during salvage operations of reject tubes where the anode support rod is removed from the anode. The benefit of using low power ultrasonic energy in this area of tube manufacture is apparent in the increased ease and speed of the operation, as well as in the elimination of parts breakage resulting in a higher yield in manufacture. A demonstration of assembly and disassembly of the anodes using ultrasonics was witnessed on August 21, 1964, by Messrs. N. Helmstetter and B. F. Steiger of Tung-Sol.

After operator training with the 600-watt welder is completed at Tung-Sol, fabrication of the Type 6080WB modified electron-tube mounts for evaluation and aging tests will be initiated.

III. COMPONENTS WELDING

A. Tungsten-Rhenium Wire Welding

Preliminary ultrasonic welding of 0.003-inch diameter tungsten-3 rhenium (W-3 Re) wire to 0.060-inch flat molybdenum, tungsten, and nickel sheet with a 100-watt welder resulted in unsatisfactory bond quality because of insufficient power and clamping force capability of the small 100-watt unit.

Additional investigations with these materials using a 600-watt welder indicate that satisfactory bonds can be achieved. Initial work was done with a welding tip of standard spherical geometry. Flattening and intrusion of the fine wire into the nickel and molybdenum was observed, and the W-3 Re wire tended to split longitudinally when welding to the tungsten sheet. A representative weld between the W-3 Re wire and 0.060-inch thick molybdenum sheet is shown in Figure 7. The intrusion and flattening effects are evident in the photomicrograph.

A grooved tip is presently being fabricated of Udimet 700, a material which was used successfully in the earlier feasibility study of the heavy (0.060-inch) wires-to-sheet welding (Quarterly Progress Reports Nos. 2 and 3). The grooved tip should reduce the intrusion of the wire into the sheet, and the restraint provided by the "nesting" of the wire in the groove should minimize the tendency of the wire to split or crack during welding. This will be pursued during the next quarter.

B. Frame-Grid Welding

Design of the frame grid for the Type 6080WB electron tube, using 0.060-inch molybdenum (unclad) side rods and a 0.003-inch gold-plated molybdenum wire-wound grid lateral wire has been completed by Tung-Sol, and component parts have been ordered. As soon as the components are available, representative frame grids will be wound by Tung-Sol and delivered to Aeroprojects for preliminary welding studies.

IV. CONCLUSIONS

Ultrasonic welding tooling and procedures have been evolved for fabrication of the modified version of the Type 6080WB electron tube. Both the welding machine and special tooling were delivered to Tung-Sol Electric Incorporated on August 3, 1964, and instruction in the use of the equipment and in the assembly sequence and tooling used in the electron-tube fabrication was given to Tung-Sol representatives.

Welding of the molybdenum frame grids cannot be initiated until component parts are received from Tung-Sol. These parts are presently in process. Welding studies with the W-3 Re wire to molybdenum, tungsten, and nickel are proceeding satisfactorily, and final tests and sample preparation will be conducted as soon as the results of modified welding tooling are completed.

PROGRAM FOR NEXT INTERVAL

Liaison and technical assistance with Tung-Sol during the operator-training period and fabrication of the sample lot of Type 6080WB electron tubes will be available as required during the next interval.

Upon receipt of the wire-wound frame grids from Tung-Sol, investigations of the welding of the lateral wire to the side rods will be initiated.

PUBLICATIONS AND REPORTS

No technical publications or reports were issued during this period. The following trips and visits were made in connection with this project:

August 19, 1964 -- Mr. J. G. Thomas visited Messrs N. Helmstetter and B. F. Steiger at Tung-Sol Electric, Incorporated, Bloomfield, New Jersey. The purpose of this visit was to supervise installation and setup of the 600-watt ultrasonic welder to be used in the Type 6080WB tube-mount fabrication, and to discuss schedules and related technical details.

August 19 through 21, 1964 -- Mr. T. A. Walraven performed installation, setup, and demonstration of the 100-watt and 600-watt ultrasonic welders at Tung-Sol. The use of the special tooling for the 600-watt welder and the assembly sequence of the Type 6080WB tube mount were demonstrated to Messrs. Helmstetter and A. Cuculo of Tung-Sol. Sample welds of each component junction were made to illustrate the use of the special tips and anvil fixtures. The 100-watt welder was set up and used also to demonstrate the advantage of using ultrasonic energy in the anode-anode support rod assembly and disassembly.

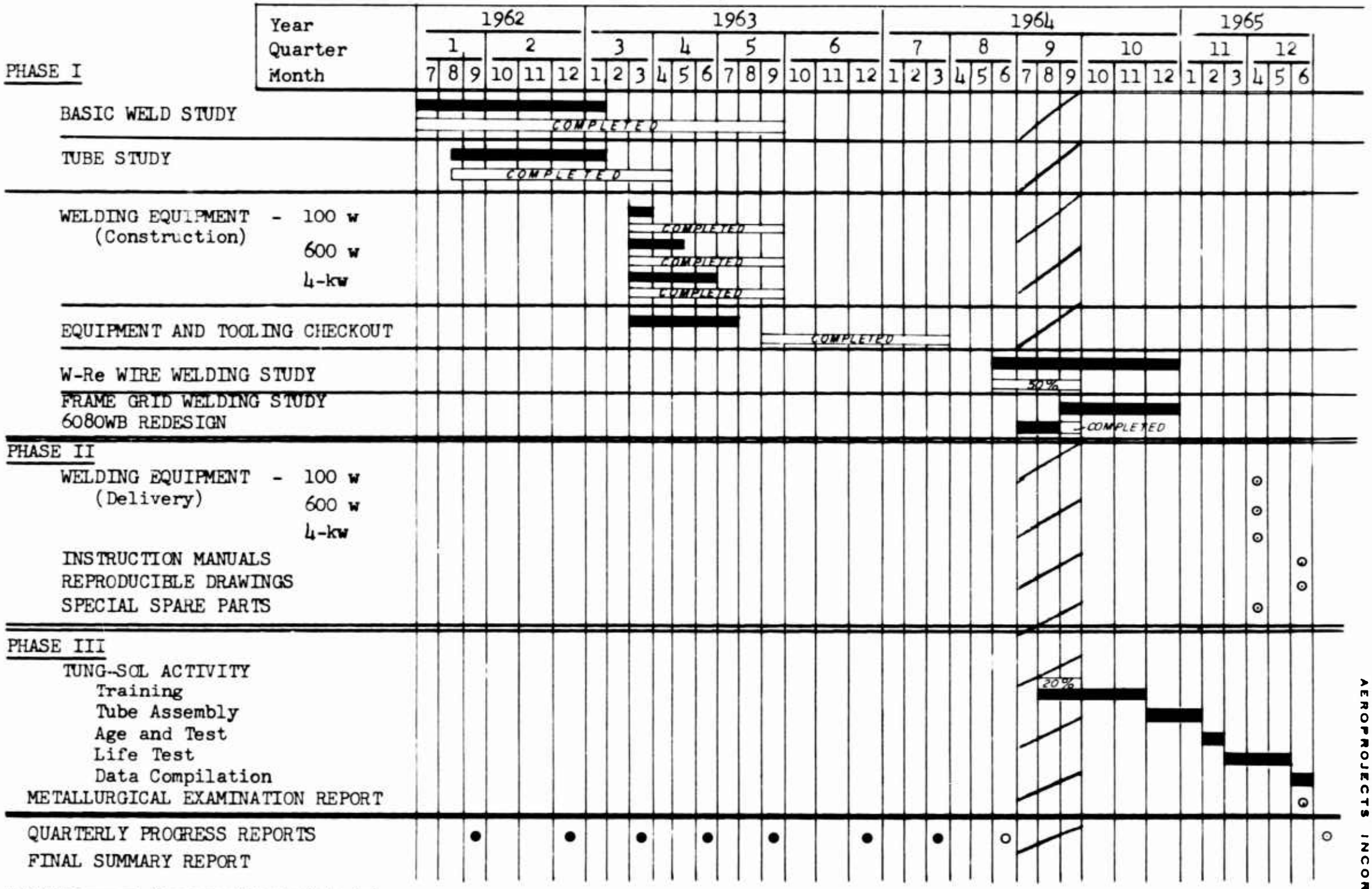
TECHNICAL MAN-HOURS

EXPENDED DURING THIS REPORT PERIOD

Aeroprojects	Project	Hours Expended During This Report Period
J. G. Thomas	Project Engineer	53-1/2
T. A. Walraven	Senior Welding Technician	95
H. L. McKaig	Vice President	1-1/2
A. L. Fuchs	Chief Design Engineer	6
Engineering		51
Shop		90
	Sub Total	297
Tung-Sol Electric Incorporated		
B. F. Steiger		0
N. Helmstetter		58
	Sub Total	58
	TOTAL	355

Technical surveillance of this contract is under the control of the Industrial Engineering Division, USAECOM, Philadelphia, Pennsylvania 19103. For further technical information contact Mr. Harry Shienbloom, Project Engineer, telephone number Area Code 215, KI-6-3200, extension 2137.

PROJECT SCHEDULE



LEGEND:
- Proposed Work Schedule
- Work in Progress
- ○ Contractual Delivery Date
- ● Contractual Item Delivered
- ⊙ Amended Delivery Date
- Present Report Period

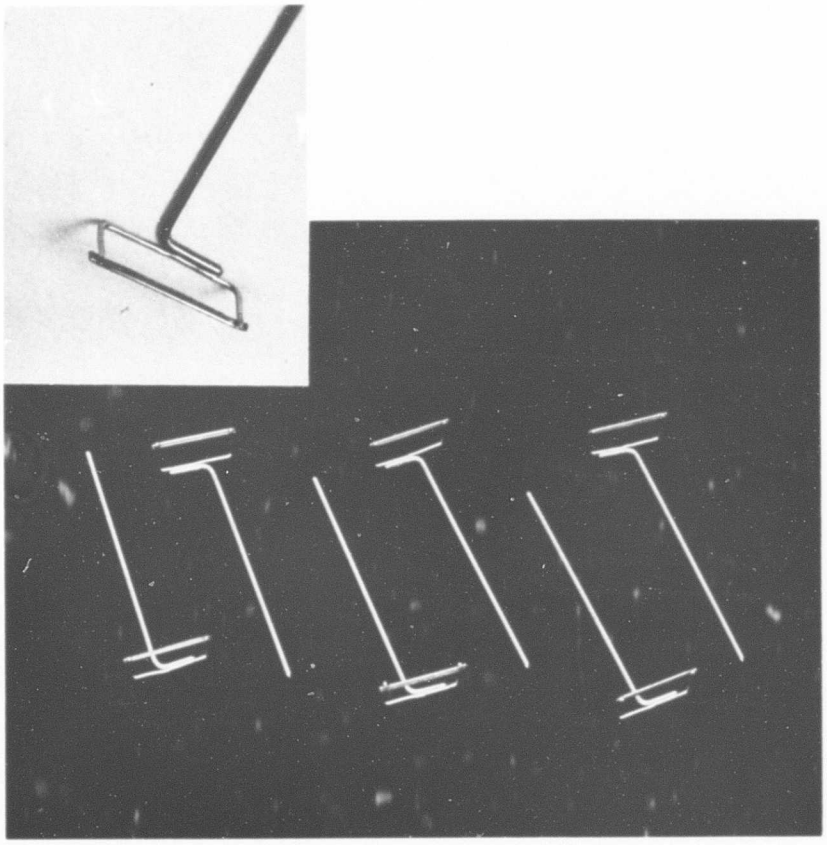


Figure 1

ULTRASONIC WELDS BETWEEN GETTER
FRAME AND SNUBBER SUPPORT ROD

Note that support rod is bent 90° to
achieve a parallel-wire weld geometry.

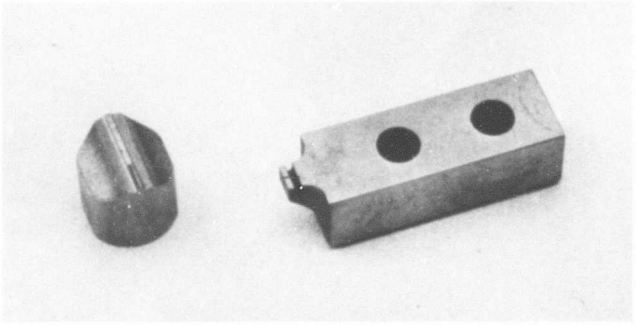


Figure 2 A

WELDING TIP AND ANVIL USED FOR JOINING
GETTER FRAME TO SNUBBER SUPPORT ROD

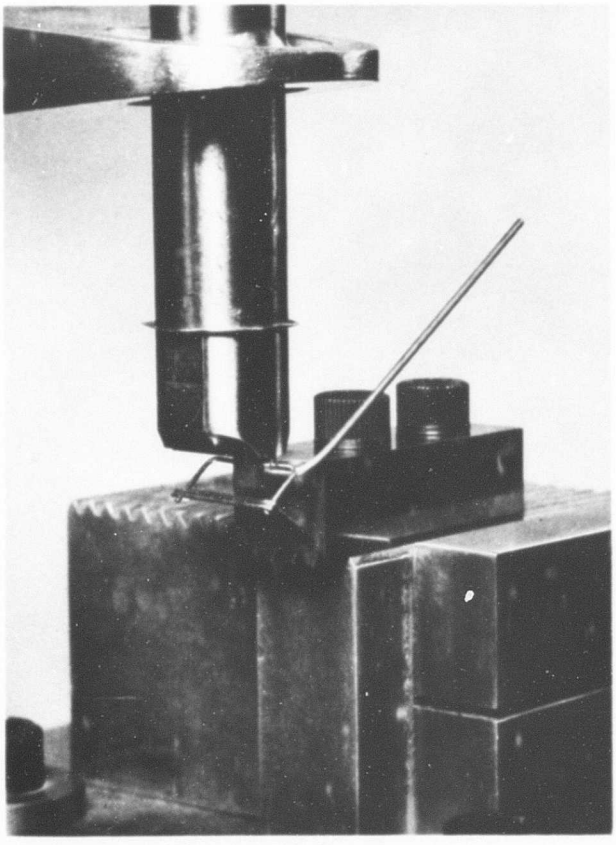
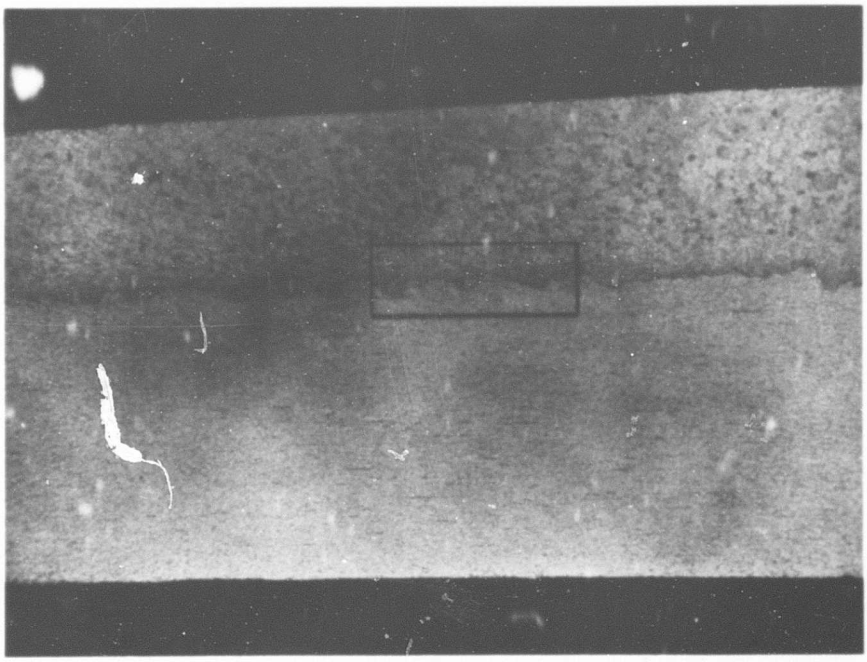
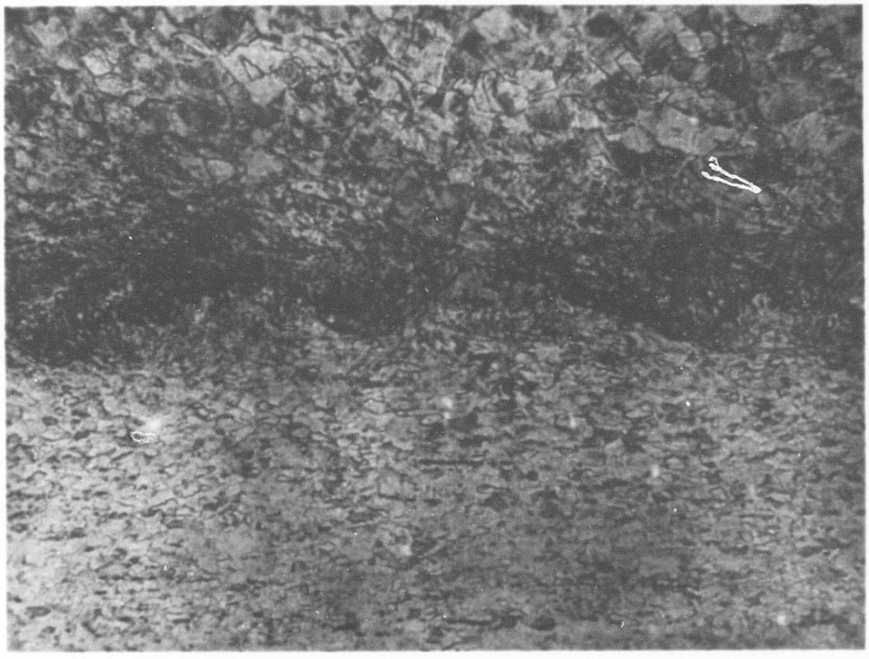


Figure 2 B

WELDING TIP AND ANVIL MOUNTED ON 600-WATT WELDER



A
(45X)



B
(200X)

Enlargement of
marked area above

Figure 3

PHOTOMICROGRAPHS OF ULTRASONIC WELD BETWEEN 0.035-INCH DIAMETER "D" NICKEL GETTER FRAME AND 0.040-INCH DIAMETER 1/2 H "D" NICKEL SNUBBER SUPPORT. PARALLEL-WIRE WELD. LONGITUDINAL SECTION.

Etch: KCN + $(NH_4)_2 S_2O_8$

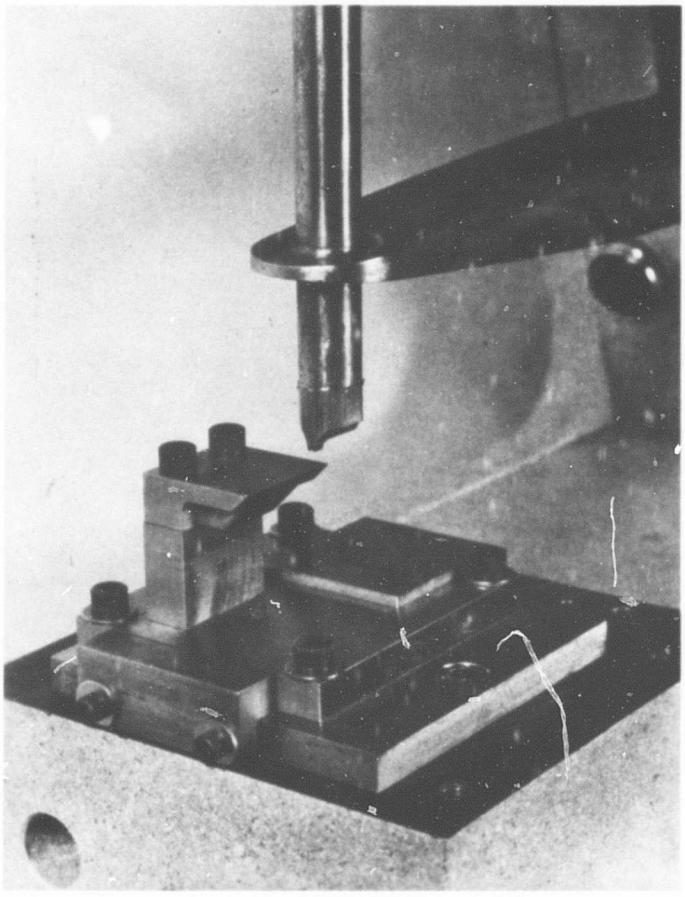
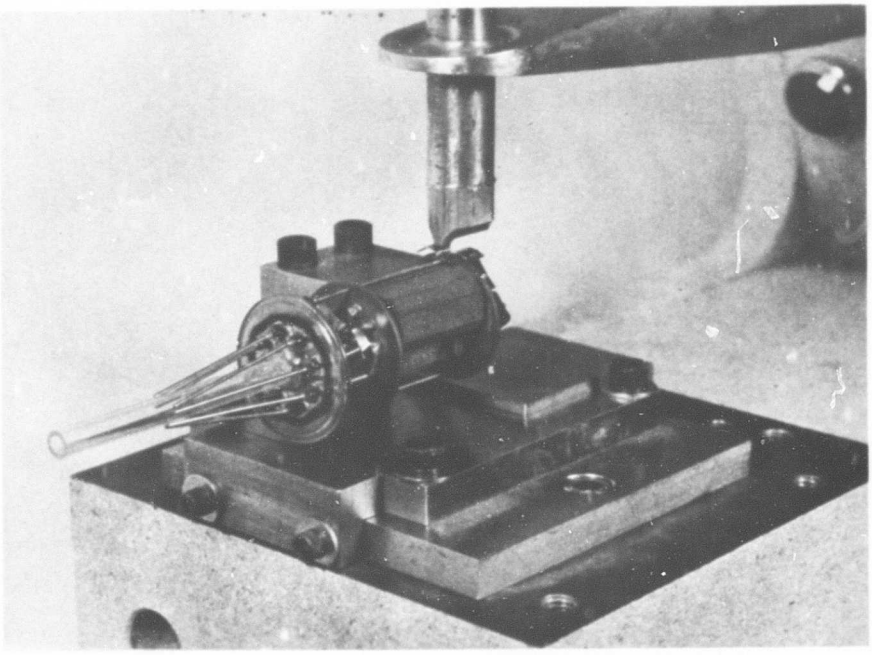
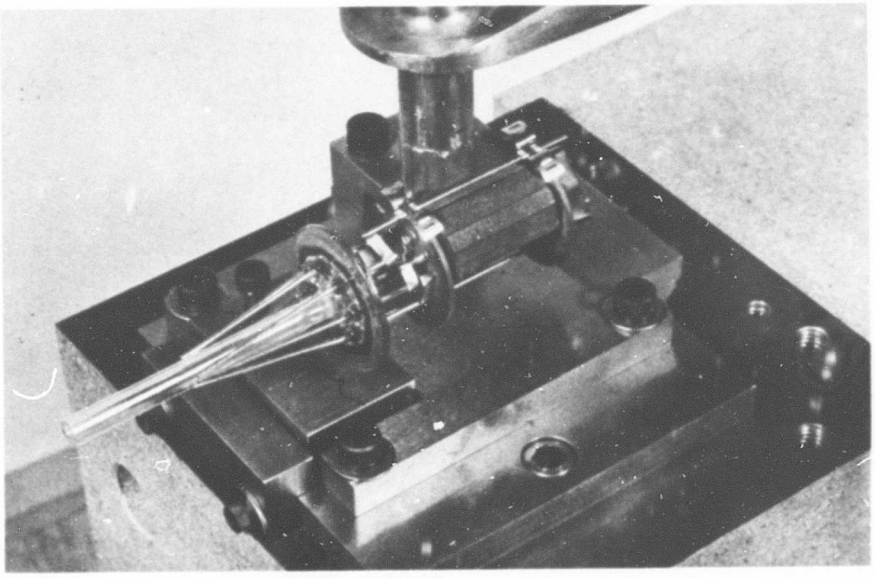


Figure 4

WELDING TIP AND ANVIL FIXTURE MOUNTED
ON 600-WATT ULTRASONIC WELDER



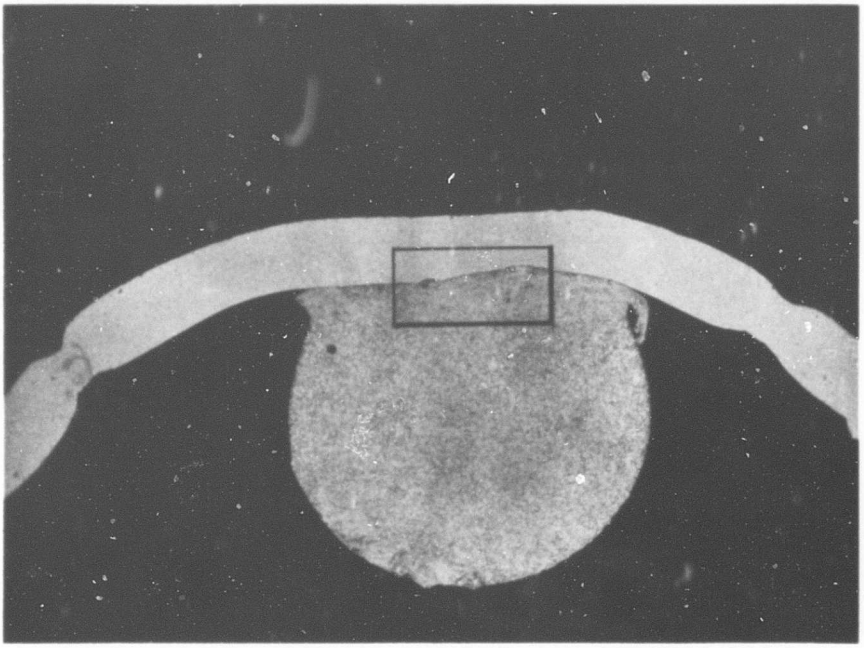
A. ANVIL IN POSITION FOR TOP SNUBBER WELD



B. ANVIL IN POSITION FOR BOTTOM SNUBBER WELD

Figure 5

WELDING SEQUENCE USED TO JOIN
SNUBBER TO SNUBBER SUPPORT ROD



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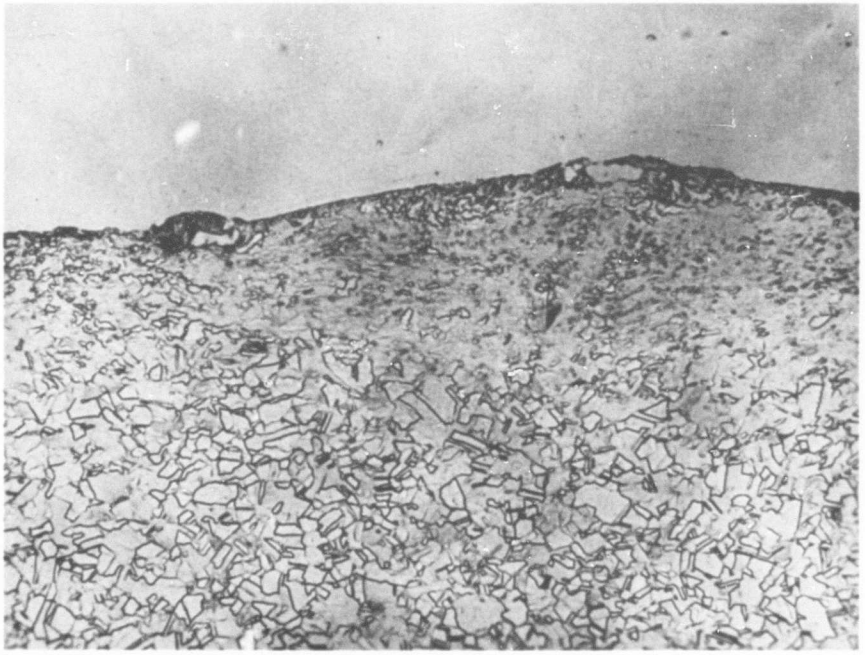

B
(200X)

Enlargement of
marked area above

Figure 6

PHOTOMICROGRAPHS OF 0.008-INCH HARD TEMPER INCONEL SNUBBER ULTRASONICALLY WELDED TO 0.040-INCH DIAMETER 1/2 H "D" NICKEL SNUBBER SUPPORT ROD. TRANSVERSE SECTION
Etch: Oxalic Acid (Electrolytic)

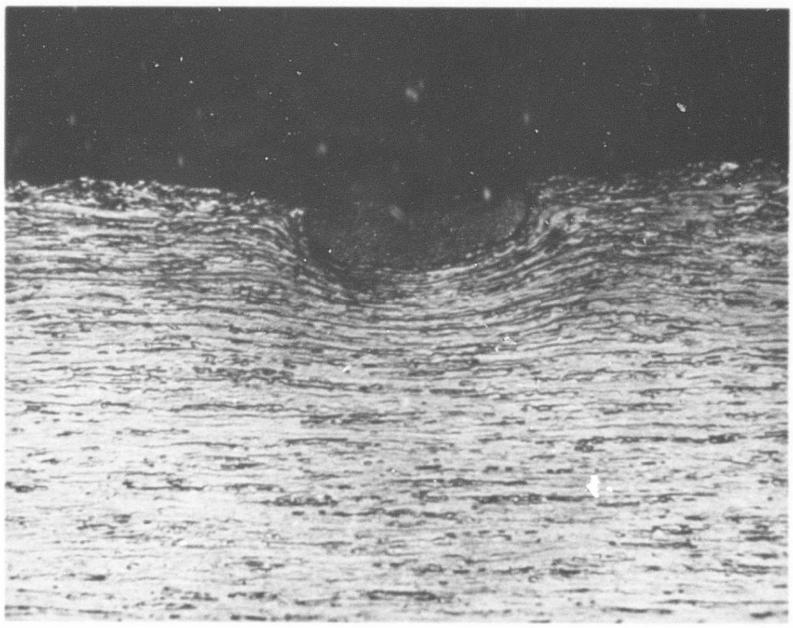

Figure 7

PHOTOMICROGRAPH OF 0.003-INCH DIAMETER W-3 Re WIRE
ULTRASONICALLY WELDED TO 0.060-INCH MOLYBDENUM PLATE
TRANSVERSE SECTION

Magnification: 200X
Etch: $KOH + K_3 Fe(CN)_6 + H_2O$